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BIOGAS PRODUCTION-REVIEW

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ABSTRACT

*Biogas is a gas produced by the breakdown of organic matter. It contains methane (**50-75%**), carbon dioxide (**25-50%**), hydrogen (**0-2%**), ammonia, hydrogen sulphide (**0-3%**) and some traces of other gases along with water vapor. There are four major stages in the production of biogas from degradable organic material which include hydrolysis, acidogenesis, acetogenesis and methanogenesis.This paper provides the fundamental procedure of formation of biogas and the factors affecting biogas production from biomass.*

Keywords: Biogas, hydrolysis, acidogenesis, acetogenesis, methanogenesis, organic matter.

1. INTRODUCTION

Biogas is a mixture of gasses produce by anaerobic digestion (fermentation) of biodegradable organic materials such as manure from animals like cows, pigs, humans etc. It is often known as "marsh gas" or "swamp gas" because it is produce by the same anaerobic process that occurs during the underwater decomposition of organic matter in wet land. [1] [19]. Biogas is a mixture of mainly methane (CH4) and carbon dioxide (CO2) with small quantities of other gases such as hydrogen sulphide (H2S), ammonia (NH4), water vapor, hydrogen (H2), nitrogen (N2) etc. the below table shows the components of biogas. [9]

Matter	**%**
Methane (CH4)	50-75
Carbon dioxide (CO2)	25-50
Nitrogen (N2)	0-10
Hydrogen (H2)	0-2
Hydrogen sulfide (H2S)	0-3
Oxygen (O2)	0-2

Table:1 Components of Biogas

Biogas isone of the most efficient and effective options among thevarious other alternative sources of renewable energy currentlyavailable. It is produced through anaerobic digestion processeswhere the microorganisms convert complex organic matter intoa mixture of methane and carbon dioxide.

2. SUBSTRATE FOR BIOGAS PRODUCTION

In general, liquid and liquified excrements ofcattle, pigs and poultry are used as basic substrate for manybiogas plants as they are easy to handle due to being pump able.In addition, liquid manure is an ideal substrate due to itsbiochemical properties. It has a high buffering capacity, containssufficient micronutrients in an available form and makesavailable the required bacteria population for the anaerobicfermentation. This refers notably to liquid cattle manure. Inaddition to liquid also solid substrates may be added tofermentation as e.g. solid manure, silages from green mass(maize silage), vinasse and pomace, rapeseed cake, plantresidues and municipal bio wastes.[1]

3. BIOGAS FORMATION

The basic principle by which biogas is produce in thedigester is the principle of anaerobic digestion. Anaerobicdigestion is a series of enzymatic processes by whichmicroorganism breakdown biodegradable organicmaterials in the absence of oxygen (O2) (17). The processoccurs in four concurrent stages.

1. Hydrolysis
2. Acidogenesis
3. Acetogenesis
4. Methanogenesis

3.1 Hydrolysis

Hydrolysis is the first step in anaerobic digestion processes. Hydrolysis simply means “rupture of chemical bond usingwater”. The word comes from a Greek root. "Hydro,"means water while "lyses" means rupture [19]). In theprocess, large organic polymers in the biomass(carbohydrates, fats and proteins) are broken down torelease simple monomers (starch, fatty acid and aminoacid). [21] On hydrolysis, polysaccharide yield mono, di,and oligosaccharide (simple sugars), Protein yield aminoacid while fats yield fatty acids. As the slurry is formed,hydrolytic enzymes become active. The hydrolyticenzymes glycoside hydrolases or glycosidases in apolysaccharide chain, target the glycosidic bond which isthe bond linking the monomers together e.g. the bondbetween glucose and fructose units (sucrose or table sugar)is a glycosidic

bond represented by an oxygen atom. Thehydrolysis of polysaccharide to soluble sugars involve thefollowing enzymes [6]

- Glycosidases acting on glycosidic bond.
- Amylases acting on starch to glucose or oligosaccharide
- Cellulase acting on cellulose to glucose or other disaccharide. (cellulase is also found in \the stomach of ruminant animals)

3.2 Acidogenesis

In the acidogenesis step, the soluble organic molecules fromhydrolysis are utilized by fermentative bacteria or anaerobicoxidizers [10]. These microorganisms are both obligate andfacultative anaerobes. In a stable anaerobic digester, the maindegradation path way results in acetate, carbon dioxide andhydrogen. The intermediates, such as volatile fatty acids andalcohols, play a minor role. This degradation path way giveshigher energy yield for the microorganisms and the products canbe utilized directly by methanogenic microorganisms [11].However, when the concentration of hydrogen and formate ishigh, the fermentative bacteria will shift the path way to producemore reduced metabolites [6]. The products from acidogenesisstep consist of approximately 51% acetate, 19% H2/CO2, and30% reduced products, such as higher VFA, alcohols or lactate[6]. Acidogensis step is usually considered the fastest step inanaerobic digestion of complex organic matter [8].

3.3 Acetogenesis

Intermediates formed during acidogenesis, consist of fattyacids longer than two carbon atoms, alcohols longer than onecarbon atom and branched-chain and aromatic fatty acids. Theseproducts cannot be directly used in methanogenesis and have tobe further oxidized to acetate and H2 in acetogenesis step byobligated proton reducing bacteria in a syntrophic relationshipwith hydrogen utilizers. Low H2 partial pressure is essential foracetogenic reactions to be thermodynamically favorable [11].The products from acetogenesis are then the substrates for thelast step of anaerobic digestion, which is called methanogenesis.

3.4 Methanogenesis

This is also known as biomethanation i.e. the formation of methane by microbes (methanogens) from O2 and H2 and or CH3COOH. Methanogens are microbes capable of producing methane as a byproduct in the absence of oxygen (anaerobically). In methanogenesis step, acetate and H2/CO2 are convertedto CH4 and CO2 by methanogenic archaea. The methanogenicarchaea are able to grow directly on H2/CO2, acetate and otherone-carbon compound, such as formate and methanol [11]. Inthe normal anaerobic digesters, acetate is the precursor for up to70% of total

methane formation while the remaining 30%originates from H2/CO2 [12]. Moreover, the inter-conversion
between hydrogen and acetate, catalyzed by homoacetogenicbacteria, also plays an important role in the methane formationpathway. Homoacetogens can either oxidize or synthesizeacetate depending on the hydrogen concentration in the system[13]. Hydrogenotrophic methanogenesis functions better at highhydrogen partial pressure, while aceticlastic methanogenesis isindependent on hydrogen partial pressure. At highertemperatures, the acetate oxidation pathway becomes morefavorable [11]. It has been reported that methane formationthrough acetate oxidation can contribute up to 14% of totalacetate conversion to methane under thermophilic conditions (60°C) [14].

4. FACTORS AFFECTING THE BIOGAS PROCESS

The factors affecting the biogas production are mainlycaused by the characteristics of the feedstock and operatingcondition of the process. Sometimes feedstock itself can containinhibitors such as high concentrations of cations. Factors from the feedstock (i.e. nutrients, pH, buffering capacityand inhibitory compounds), and operating conditions such as temperature influence directly on the performance ofmicroorganisms.

5. CONCLUSION

The activities of enzymes and microorganism in thebiodigester bring about biogas production. Identifyingthese enzymes and microorganism and their specific roles,is a way forward in the commercialization of biogas as thismakes it easy for such enzymes to be isolated and themicroorganism cultured for artificial production.

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